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Then in one adopted year

$$\text{Rotation (Bessel)} = \frac{\text{H}+\text{L}-\varpi}{1+x}$$

$$\text{,, (Hansen)} = \frac{\text{H}'+\text{L}'-\varpi'}{1+x'}.$$

And we thus have

$$\frac{1+x'}{1+x} = \frac{\text{H}'+\text{L}'-\varpi'}{\text{H}+\text{L}-\varpi}, = 1 + \frac{\text{H}'-\text{H}+\text{L}'-\text{L}-(\varpi'-\varpi)}{\text{H}+\text{L}-\varpi}.$$

Here

$$\text{H}'=\text{H}, = 365{\cdot}25 \times 360° = 131490°, = 473364000'', \text{H}+\text{L} = 474660027,$$
$$= \text{about } 366\text{L}: .$$

hence we have

$$\frac{1+x'}{1+x} = 1 + \frac{\text{L}'-\text{L}-(\varpi'-\varpi)}{366\text{L}}.$$

Or neglecting as before $\varpi'-\varpi$, the ratio is

$$= 1 + \frac{0''{\cdot}055871}{366\text{L}};$$

viz. the alteration of ratio is $=\frac{1}{366}$ of the value found by Mr. Stone. As regards the term $\varpi'-\varpi$, Bessel's precession is 50″·21129, Hansen's 50″·224, whence

$$\varpi'-\varpi = 0''{\cdot}01271\ (1-\cos 23°\ 28') = 0''{\cdot}01271 \times {\cdot}0898, = 0''{\cdot}00114;$$

so that instead of 0″·055871 the numerator should be 0″·05473.

The Orbit of the Great Comet (*b*) 1882. By J. Morrison, M.A., M.D., Assistant on the *American Ephemeris and Nautical Almanac*, Washington.

(*Communicated by the Foreign Secretary.*)

Ever since the discovery of this remarkable comet in the early part of September 1882, numerous efforts to determine the elements of its orbit have been made by astronomers in different parts of the world, and in no similar case has there been, we believe, a greater disparity in the results obtained. An orbit like the one under consideration, which is so situated with respect to the orbits of the planets that the effect of planetary perturbations is absolutely inappreciable, must furnish a good example of pure and undisturbed elliptic motion, and therefore we would naturally expect that a system of elements computed from three or four good observations suitably selected would very nearly, if not exactly, represent its motion. In this expectation, however, we are disappointed, for no orbit has hitherto been published which completely satisfies the observations, especially those made after the middle of October or thereabouts. From the time of discovery until about this date the nucleus

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presented a tolerably well-defined circular disk which could be as easily observed as that of a planetoid; but soon afterwards extraordinary changes began to take place in the structure of the nucleus, which, from being circular in outline, became oval or elliptical, with from two to four or five bright points or centres of condensation. Thus, from about October 20 until May 26 the length of the nucleus varied from 57″ to about 135″, and the position-angle of its major axis varied from 113° to 255°—which is nearly at right angles to the meridian—hence it is not difficult to see that an error of 30″, or even more, in R.A., may exist in any observation made about this time, according to the point of the nucleus observed. The error in Declination will be much less than that in R.A. for the reason given above. The following two observations made at the Litchfield Observatory, Clinton, N.Y., and at the Naval Observatory, Washington, are here adduced to show the inconsistency of the results obtained when different points of the nucleus were observed:—

Washington Mean Time.		R.A.	Dec.
		h m s	° ′ ″
1882, Oct.	24·712191	10 6 25·78	−17 6 48·2
	24·739461	10 5 52·29	−17 5 6·8

According to the geocentric motion of the comet at that time these observations are inconsistent with each other, and therefore of little or no value in the present investigation. That the discrepancy is due to this cause alone is evident from the fact there were no errors in the position of the comparison star or in the reduction of the observations, which were re-examined by the observers. It is therefore not at all suprising that periods differing very widely from each other have been obtained by different computers, according to the observations employed. Thus, from post-perihelion observations Mr. Chandler obtained periods of 3115 days and 4070 years respectively, and between these extremes we have periods of 269, 652, 712, 793, 843, 997, and 1376 years. The most probable period is between 712 and 793 years, as will appear presently. With the view of comparing the elements obtained from observations made after perihelion passage with those deduced from observations made before and after that epoch, we select the following observations:

	Washington Mean Time.		R.A.	Dec.	Where made.
		d	c ′ ″	° ′ ″	
1	1882, Sept.	8·113405	144 16 52·5	− 0 57 46·4	Windsor
2		8·452672	144 59 51·4	− 0 56 30·0	The Cape
3*		14·348690	161 28 20·0	+ 0 4 12·9	Melbourne
4*		16·368673	170 39 26·3	+ 1 12 4·8	„
5		16·936700	Ingress on Sun's disk.		The Cape
6*		19·969786	168 34 57·6	− 0 34 28·5	Washington
7	Oct.	8·720457	157 1 37·9	−10 40 21·9	„

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	Washington Mean Time.	R.A.	Dec.	Where made.
	d	° ′ ″	° ′ ″	
8	27·710103	150 31 33·9	−18 14 31·1	Clinton
9*	Nov. 15·740418	141 57 40·8	−24 49 18·9	Washington
10*	24·700923	136 34 3·3	−27 21 26·7	,,
11*	Dec. 11·619921	124 5 25·3	−30 16 28·1	,,
12	1883, Jan. 13·778694	100 3 54·9	−26 48 39·5	Windsor
13	Feb. 28·304652	87 56 18·0	−15 16 7·1	Washington
14	Apr. 6·097128	89 31 28·9	− 9 4 49·2	Palermo
15	May 6·252250	93 32 12·6	− 6 21 30·3	Cordoba
16	26·257880	97 11 12·6	− 5 30 0·0	,,

These observations embrace nearly the entire period of visibility of the comet. No. 7 was made with the equatorial, the comparison star being a well-known one, whose position was subsequently verified by the Transit Circle; No. 8 is marked by the observer as "very good;" in Nos. 9 and 11 the "main point of condensation near the following end of the nucleus was observed," and in 13 "the middle point between the second and third points of the nucleus." No remarks respecting the remaining observations are made by the respective observers.

From Nos. 6, 7, and 13 we have obtained the following system of elements:—

I.

T	1882, Sept. 17·00858 Washington M. T.
	° ′ ″
ω	69 37 27·7 Mean Equinox of 1882·0.
☊	346 1 38·8
i	38 0 7·7
log. q	7·8922566
log. e	9·9999660
log. a	1·9992346
P	997·36 years. Motion retrograde.

These elements, although computed with great care, do not represent the motion in the neighbourhood of perihelion. The residuals for the middle place are much greater than what would likely be due to the unavoidable errors of computation and observation. Among quite a number of places computed the smallest residuals obtained were the following:—

		$\Delta\lambda \cos\beta$	$\Delta\beta$
		″	″
3	Sept. 14·34+	+27·21	+17·20
9	Nov. 15·74+	−24·49	+12·53

It is very probable that a slight error in the third place has to some extent vitiated these results. The interval between the first and third observations is 161·3247 days, during which time the comet described an arc of only 16° 12′·1, an amount of motion far too small to permit of an accurate determination of

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* Meridian observations.

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the elements, especially in orbits like the present one, whose eccentricity is very large.

For the computation of a second system of elements, we will take observations which give a large amount of motion, and therefore select the three meridian observations of September 14, September 19, and November 15; the last being the first meridian observation made after the comet had ceased to be visible in daylight, and had passed from the immediate vicinity of the Sun. At this time, too, the process of disintegration in the nucleus had not advanced very far, and from the remark appended to the observation it is very probable that it is very nearly as accurate as either of the other two about which there is no doubt.

In order to show the degree of accuracy to which the computation has been carried we here give the results of the last two hypotheses. The notation is the same as that used by Gauss in his *Theoria Motus*, with the exception that we have employed u to denote the argument of latitude and ρ the curtate distance. The ratio of the sector to the triangle corresponding to the first and second observations, and also to the first and third, is *negative* and numerically less than unity.

	I.	II.
log. P	9·5492503*n*	9·5492433*n*
log. Q	8·4458408*n*	8·4458447*n*
$\omega+\sigma$	2° 25′ 49″·788	2° 25′ 50″·016
log. Qc sin ω	0·3691234	0·3691230
z	48° 1′ 1″·943	48° 1′ 1″·936
log. r'	9·3402558	9·3402558
log. ρ'	0·0539758	0·0539758
log. ρ	9·9972618	9·9972631
log. ρ''	0·0734265	0·0734271
log. r	9·3097846	9·3097852
log. r''	0·2226261	0·2226265
☊	346° 0′ 41″·385	346° 0′ 41″·254
i	38 0 7·03	38 0 7·19
$\frac{1}{2}(u''-u)$	164 52 45·703	164 52 47·13
$\frac{1}{2}(u'-u)$	157 55 32·977	157 55 34·27
$\frac{1}{2}(u''-u')$	6 57 12·726	6 57 12·86
log. η	0·1412227	0·1412226
log. η''	9·5876330*n*	9·5876319*n*
log. $P_{,}$	9·5492420*n*	9·5492433*n*
log. $Q_{,}$	8·4458464*n*	8·4458450*n*
x	+0·0000083	0·0000000
y	−0·0000056	−0·0000003

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The three values of log p, the semi-parameter, are each equal to 8·1905156, which proves the accuracy of the entire computation up to this point. On completing the computation of the elements from these results, we have the following system :—

II.

T	1882, Sept. 17·010163 Washington M.T.
ω	69° 35′ 30″·483 Mean Equinox of 1882·0.
☊	346 0 41·254
i	38 0 7·19
log. q	7·8895067
log. e	9·9999578
log. a	1·9016841
P	712·10 years. Motion retrograde.

The residuals for the middle place are zero. It now remains to be seen how closely these elements satisfy the above observations.

The residuals are given in the following table, where C—O denotes, as usual, the difference between the *computed* and the *observed* places, and Δ the distance from the earth.

C – O.

	$d\lambda \cos\beta$	$d\beta$	log. Δ
	″	″	
1	− 3·71	− 0·28	0·0604274
2	− 0·75	+ 1·02	0·0569198
4	+ 1·60	+ 0·82	9·9900265
7	− 0·16	− 0·44	0·1406414
8	+ 1·01	+ 0·37	0·1662759
10	+ 0·92	− 1·12	0·1766315
11	+ 13·41	+ 6·45	0·1916736
12	− 61·20	+ 37·52	0·2798283
13	− 45·68	+ 3·82	0·4629200
14	− 52·12	− 27·24	0·5880931
15	− 64·07	− 31·20	0·6640691
16	− 54·12	− 20·74	0·7022010

Transit over the Sun's Disk.

The ingress on the Sun's disk took place on September $17^{d}\ 4^{h}\ 50^{m}\ 58^{s}$, Cape mean time, according to Mr. Finlay, and at $4^{h}\ 50^{m}\ 52^{s}$, according to Dr. Elkin (*Monthly Notices*, November 1882). Adopting the former and applying the correction for aberration, which is -0^{d}·005698, we have for the position of the comet the following results :—

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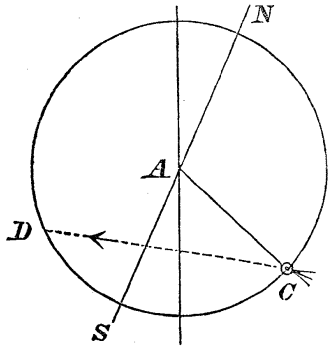
Washington Mean Time.	λ	β	log. Δ
	° ′ ″	° ′ ″	
1882, Sept. 16·931001	174 27 19·83	−0 13 12·39	9·9952130
Sun's position, ⊙ ...	174 36 19·06	−0 0 0·22	
Difference ...	0 8 59·23	13 12·17	

	′ ″
Distance between the centres	15 58·28
Sun's semi-diameter	15 57·73
Comet's distance from Sun's limb ...	0·55

The diagram shows the position of the comet with respect to the Sun at the time of ingress.



N S is a meridian; C D the apparent path of the comet; N A C the angle of position, 122° 23′·7 from the north point of the Sun's limb towards the west.

Since this second system of elements represents the motion of the comet with great accuracy from the time of discovery till about the middle of November, and from this date until the last observation here recorded, with all the precision that can be expected under the circumstances, we may also give the following facts as tending to show more strongly perhaps the characteristics of this remarkable body.

At the time of ingress on the Sun's disk the comet's true anomaly was 92° 7′ 29″·668, which was described in *one hour and fifty-four minutes*. From the time of the first observation made at Windsor by Mr. Tebbutt until May 26th, an interval of 260·1447 days, the comet described 340° 22′·7 of its orbit, but it will require more than seven centuries to describe the remaining 19° 37′·3. Taking the mean solar parallax at 8″·848, the value adopted in the English and American *Nautical Almanacs*, the comet's perihelion distance was 716200 miles from the Sun's centre, or 285500 miles from the surface.

The velocity at perihelion was 295·36 miles per second, which is only ·0160 miles per second less than that due to a parabola at the same perihelion distance.

When the comet reaches aphelion, it will have plunged down into space a distance equal to 160 radii of the Earth's orbit, or 5½ times the radius of *Neptune's* orbit, at which enormous distance its velocity will be only 75 feet per second.

At the time of Dr. Elkin's first observation on Sept. 8, the apparent diameter of the coma was estimated at from 40″ to 50″, and the strongly condensed cone or nucleus in the centre at from 10″ to 15″. Assuming the means of these measurements,

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we easily find the diameter of the coma at that time to have been 22500 miles, and of the nucleus 7600 miles, or a little less than that of the Earth. As the comet approached the Sun, the nucleus contracted, and about half an hour before its disappearance on the solar disk Mr. Finlay found by two micrometric measures the apparent diameter to be 4″, while Dr. Elkin estimated it at some 5″. The former of these gives a diameter of 1770 miles, and the latter 2215 miles, or a little greater than that of the Moon.

The second system of elements here presented proves conclusively that an orbit can be found which satisfies the motion of the body equally well both before and after perihelion; and therefore we may safely conclude that no retardation occurred during the perihelion passage; or, if there was, it is absolutely inappreciable. There are two other systems of elements which differ considerably in the periodic time from our second system, but the agreement of some of the other elements is very remarkable. We refer to those of Prof. Frisby and Dr. Kreutz; the former founded his calculations on the observations of Sept. 19, Oct. 8, and Nov. 24, and the latter on normal places derived from observations extending from Sept. 8 to Nov. 15. The three systems just referred to are here given for comparison.

	Dr. Morrison.	Prof. Frisby.	Dr. Kreutz.
T*	1882, Sept. 17·010163	1882, Sept. 17·0088	1882, Sept. 17·00993
ω†	69° 35′ 30″·48	69° 36′ 12″·79	69° 36′ 1″·50
☊	346 0 41·25	346 1 7·91	346 1 27·20
i	38 0 7·19	38 0 7·84	38 0 19·9
log. *q*	7·8895067	7·8904739	7·8894760
log. *e*	9·9999578	9·9999606	9·9999610
log. *a*	1·9016841	1·9331366	1·9505596
P	712·10 yrs.	793·869 yrs.	843·10 yrs.
	Mean Equinox 1882·0	Mean Equinox 1882·0	Mean Equinox 1882·0

* Washington Mean Time. † Motion retrograde.

This comet is probably identical with the comet of 370 B.C., as already pointed out by Mr. Maxwell Hall. If we divide the interval between 370 B.C. and 1882 A.D. by three we get a period of 751 years, which is very nearly the arithmetic mean between our period and that of Prof. Frisby. This period would give a return in A.D. 1131 or 1132, in both of which years a great comet appeared (*Chinese Annals*).

Observations of Pons's Comet made at the U.S. Naval Observatory, Washington, with the 9-inch Equatorial.

By Commander W. T. Sampson and Prof. E. Frisby.

(*Communicated by the Secretaries.*)

1883.	Washington M.T.	Comet—*		No. of Comp.	Comet α app.	log. $(p\times\Delta)$	Comet δ app.	log. $(p\times\Delta)$	Obs.	Comp. Star.
	h m s	Δα m s	Δδ ′ ″		h m s		° ′ ″			
Sept. 23	8 8 24·5	+0 1·19	− 2 10·3	15·3	16 25 20·93	9·89564	+60 31 56·8	9·72026*n*	S	1
24	11 19 47·3	+4 57·92	− 2 12·9	15·3	16 25 28·49	9·94552	60 16 47·8	0·76095	S	2
26	7 42 33·3	− 31·98	−10 10·6	25·5	16 25 47·71	9·87342	59 52 22·8	9·82982*n*	S	3
26	9 56 0·3	+0 16·86	+ 7 7·4	18·4	16 25 47·07	9·96138	59 51 16·0	0·41280	F*	4
28	8 9 12·4	−2 4·47	− 9 35·9	20·3	16 26 17·22	9·91121	59 26 16·6	9·38115	F	5
30	9 39 24·7	+3 32·05	− 5 24·4	5·1	16 27 5·26	9·94484	58 58 54·6	0·57845	S	6
30	9 50 37·1	+3 32·02	− 5 12·4	5·1	16 27 5·23		58 58 42·6		S	6
Oct. 2	9 30 9·2	+1 39·78	+ 3 46·8	25·5	16 28 2·02	9·30293	58 33 52·3	9·51845*n*	S	7
2	9 30 9·2	+3 12·29	+ 3 19·9	25·5	16 28 2·41		58 33 51·8		S	7
8	7 43 21·6	−0 48·60	+ 6 4·3	25·5	16 32 2·33	9·88741	57 16 55·5	9·73798	S	9
9	7 17 34·7	0 0·00	− 6 27·7	10·2	16 32 50·90	9·87016	57 4 23·3	9·39904	S	9
9	7 24 12·3	0 0·00	− 6 31·6	10·2	16 32 50·90		57 4 19·4		S	9
10	7 22 41·5	−9 20·48	− 7 57·0	15·3	16 33 43·74	9·86011	56 51 49·0	7·65475	S	10
11	7 54 46·7	+8 5·37	−12 44·3	15·3	16 34 39·90	9·89986	56 38 56·5	0·09116	S	11
11	8 6 16·5	+8 6·21	−12 50·3	10·2	16 34 40·74		56 38 50·5		S	11
19	9 3 14·1	−6 37·23	+ 4 45·5	10·2	16 43 45·76	9·90472	55 1 19·7	0·48745	F	12
24	6 52 24·8	+2 7·06	+ 5 20·8	15·3	16 50 49·66	9·84559	54 4 23·8	9·87235	S	13

* Made with 26-in. Equatorial.

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